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Quebec Region
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Science Advisory Report 2011/063

ASSESSMENT OF THE SEA CUCUMBER FISHERY IN THE ESTUARY AND NORTHERN GULF OF ST. LAWRENCE FROM 2008 TO 2010

Photo: Jean-Paul Dallaire

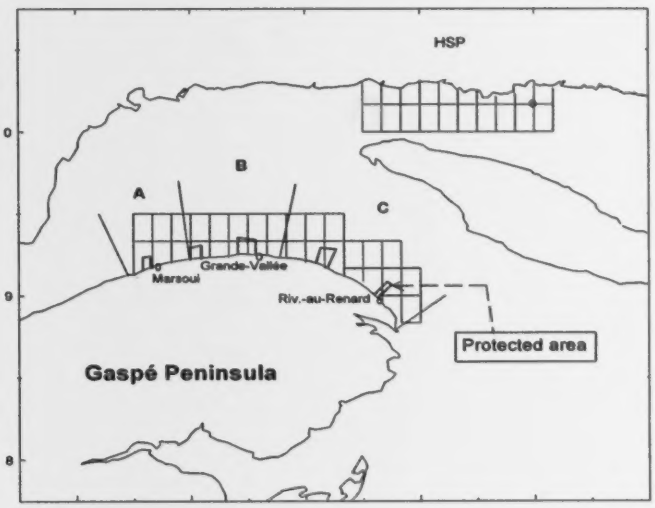

Figure 1. Sea cucumber management units (Units A, B, C and HSP) in Quebec and protected areas.

Context:

The sea cucumber (Cucumaria frondosa) fishery is a recent activity in the Estuary and northern Gulf of St. Lawrence. It began in 2008 on the Gaspé Peninsula's north shore and in 2009, it extended to the Middle North Shore near Havre-Saint-Pierre. This fishery is carried out either by diving or by using an LGS-type dredge or a dredge specifically designed for sea cucumbers. The cucumbers are processed at a plant in Maine, and products are exported mainly to Asian markets. There is currently no local market.

In 2004, on the Gaspé Peninsula, a study was conducted by Campagna et al. (2005), to determine the potential of this fishery. Following this study, an initial exploratory license was issued in 2008 for Unit C. The following year, three additional exploratory licenses were issued. A project funded by the Fisheries Science Collaborative Program (FSCP) was carried out on the North Shore in 2010 to assess the fishery potential around part of the Mingan region. This is the first assessment for the sea cucumber fishery in the Estuary and Northern Gulf of St. Lawrence.

Canada

SUMMARY

Fishery

- The sea cucumber fishery began in Quebec in 2008 and is still in the exploratory stage. Landings amounted to 676 t in 2010, most of which came from Unit C on the Gaspé Peninsula's north shore and from Unit HSP (Havre-Saint-Pierre) in the Mingan region.
- The mean CPUE was comparable in all units in 2009 and 2010 except Unit B on the Gaspé Peninsula's north shore, where effort was reduced in the spring and concentrated at the end of the season.
- The mean size of sea cucumbers caught by dredging was greater than 130 mm in all units. Over 70% of sea cucumbers caught measured over 100 mm, which corresponds to the estimated minimum size at sexual maturity.

Research Survey

- Heterogeneity in sea cucumber abundance was observed all across the study areas, both in the commercial fishery and in the research survey conducted in the Mingan region in 2010. The largest concentrations were observed in the western Mingan region.
- The research survey showed that smaller individuals are generally found in the shallowest strata, which serve as nursery sites for the species.
- Green sea urchins were the most common type of by-catch in the survey. The fishing sites in the survey did not necessarily contain sea cucumbers at a density high enough for a commercial sea cucumber fishery.

Gear

- More than fifteen species were caught unintentionally in the commercial fishing gear in 2009 and 2010.
- A study of the short-, medium- and long-term impacts is needed to determine the effect of the gear on sea cucumber habitat and on the benthic communities where the fishery is carried out. In particular, more information is needed on the short-term impacts of drag fishing on marine ecosystems in the Gaspé Peninsula's north shore.

BACKGROUND

Species Biology

The sea cucumber, *Cucumaria frondosa*, is an echinoderm with a wide geographical distribution in the north Atlantic and Arctic oceans. In North America, it is found in most habitats in the Estuary and the Gulf of St. Lawrence, and as far south as Cape Cod. The sea cucumber lives in depths of less than 10 m during its early years and later migrates very slowly to depths of up to 60 m. However, it can be found at depths of over 400 m. It has five rows of tube feet that allow it

to move and to attach to substrates. It prefers complex rocky bottoms or mixed substrates of gravels, stones, sand and shells. The sea cucumber feeds on phytoplankton and zooplankton by spreading out its ten tentacles, which capture plankton suspended in the water column or sitting nearby on the substrate. The tentacles are covered with sticky mucus, which aids in harvesting. Each tentacle is retracted individually into the sea cucumber's mouth, where the plankton is then eaten. The species has very low mobility. Sea cucumbers gather in aggregations known as "beds"; this behaviour ensures a certain level of success in reproduction, which is achieved by external fertilization.

According to the data available for Quebec, sea cucumber spawning occurs in mid-June-later than that observed in the Bay of Fundy (April–May), Newfoundland (February–May) and Maine (March–April). The sea cucumber has separate sexes but does not exhibit sexual dimorphism. New larvae undergo an initial 48-hour pelagic phase, after which they settle, preferring the undersides and sides of gravel as well as rocks with crevices.

According to Quebec data, the upper limit of the estimated minimum size at sexual maturity is 102 mm, which corresponds to an age of roughly 5 years. With these numbers, cucumbers would live up to 10 years old. However, a recent study conducted in Newfoundland (So et al., 2011) indicates that the species would need a minimum of 25 years just to reach a size of 150 mm. Although conditions for growth can be harsher on the St. Pierre Bank in Newfoundland than in the Estuary and the Gulf of St. Lawrence, if the growth rate is in fact slower than previous estimates suggest, sea cucumbers would be less tolerant to the same level of fishing pressure. The maximum size observed on the North Shore and in the Gaspé Peninsula in all three years of fishing was 240 mm.

Protecting at least one natural bed in each management unit is often recommended as a conservation measure for this species in order to ensure a certain reproductive success.

Fishery

Two different methods are used to harvest sea cucumbers. The first method, dive fishing, consists of diving underwater and removing the animals, either with or without the use of a siphon connected to a pump at the surface. Using the siphon usually requires two divers working together to operate the gear. The divers go on four to six dives per day, the average dive length being one hour. The second method, drag fishing, is currently more common and consists of towing a dredge behind a fishing boat. The dredges used in Quebec are lighter and more compact than the LGS (Light Green Sweep Urchin) drag type, which was developed from a scallop dredge in the United States for harvesting green sea urchins. In Quebec, sea cucumber dredges vary in width depending on the unit in which they are used: 2.4 m in Unit HSP, 3 m in Unit B and 3.7 m in Unit C. The height of the dredges varies from 0.25 to 0.5 m.

The first trial of sea cucumber fishing in Quebec was conducted in 2008 in Unit C, in the northern part of the Gaspé Peninsula (Figure 1). Catches for this trial totalled 201 t. The following year, the fishery was extended to Unit B (also in north Gaspé), to Unit HSP (in the Mingan region), and to Unit A in north Gaspé where underwater diving was used. A minimum size of 116 mm was introduced only in Unit HSP. The total catch for all units in Quebec was 595 t in 2009 and 676 t in 2010. In 2010, protected areas were established along the Gaspé coast corresponding to about 15% of the entire coastal territory (Figure 1). Fishing depths varied somewhat by unit: under 20 m in Unit A, 22 to 36 m in Units B and C and over 20 m in Unit

HSP. To date, only one permit has been issued for each unit. The fishery is still in the exploratory stages.

In Units A, B and C, fisheries are managed by TAC, which corresponds to a set percentage of the estimated biomass in each unit; this estimate is based on information obtained in the preliminary inventory, which was taken in 2004 (Campagna *et al.*, 2005). In Unit HSP, the fishery is managed by effort control, i.e. by limiting the number of fishing days each season. The limit was 70 days in 2010.

ASSESSMENT

The data on fishing effort and CPUE used in this assessment come from the harvesters' logbooks. The size structures and mean sizes of sea cucumbers were taken from the DFO landed commercial catch sampling program and from samples taken by at-sea observers (Biorex). The harvest positions for both drag fishing and dive fishing were obtained from logbooks.

Dive Fishery

Because there were too many by-catch species in the exploratory fishing conducted in 2004, only dive fishing is permitted in Unit A (north Gaspé), which has a total allowable catch (TAC) of 800 tonnes. While diving is the preferred means of exploiting the sea cucumber because it minimizes impact on the habitat, only one diving trial was conducted in the summer of 2009. This trial proved unprofitable because of prohibitive operating costs, so the harvester decided to halt the trial after only nine days. By that point, the total dive time had come to 40 hours with landings totalling 23 tonnes.

Drag Fishery

A recent form of harvesting in Quebec, drag fishery first began in Unit C, in the north Gaspé Peninsula (Figure 2) in 2008. In Units B and C, commercial fishery landings were less than the TAC. For Unit B, the TAC was set at 600 t (200 t in the spring and 400 t in the fall) for 2009 and 2010. Landings totalled only 135 t in 2009 and 23 t in 2010, the year in which effort was lowest and the fishery was done only at the end of the season, in the fall (Table 1). The two-year mean catch per unit of effort (CPUE) was 234 kg/hm (kilograms per hour/meter). In Unit C, an initial and preventive TAC of 200 t for 2008 was subsequently increased to 800 t in 2009 and 2010 (300 t in the spring and 500 t in the fall). However, catches plateaued at 324 t in 2009. The mean CPUE in Unit C, 401 kg/hm, was the highest of all the management units.

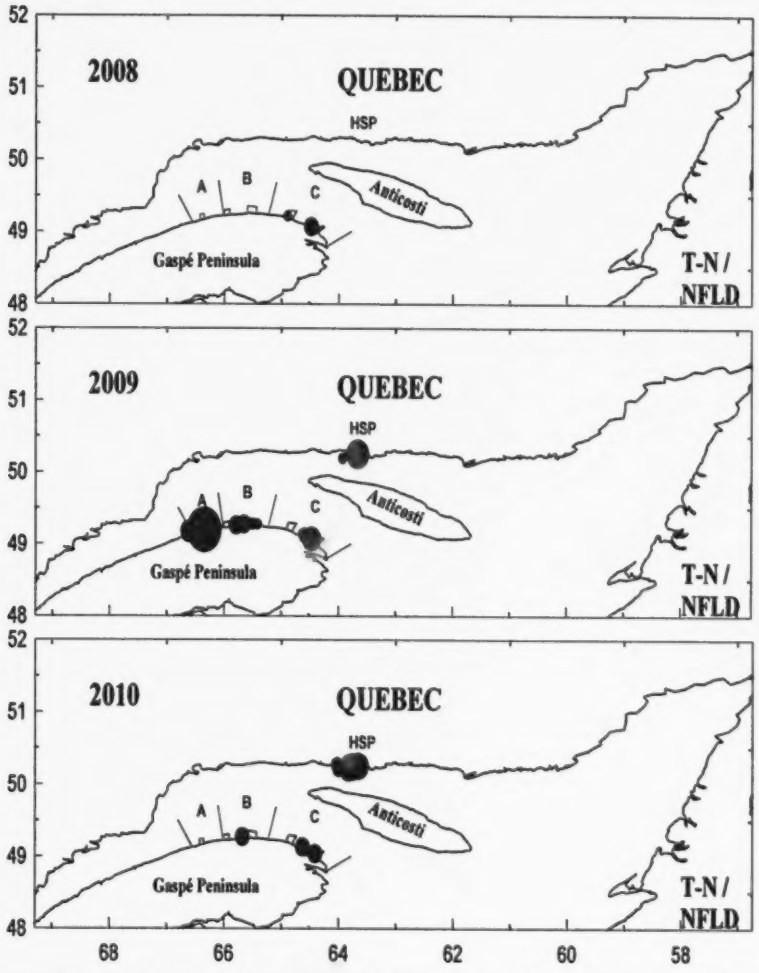

Figure 2. Sea cucumber fisheries in Quebec from 2008 to 2010. The size of the circles represents the relative fishing effort (number of trips made) in that position.

In Unit HSP, the number of fishing days was 68, close to the fishing effort limit of 70 days for 2010. Sea cucumber landings were 361 t. The mean CPUE of 242 kg/hm was comparable to that of Unit B, while the distribution of fishing effort was lower than that in Unit C. Although the fishery is relatively new in Unit HSP, it is already possible to identify certain sites where cucumbers appear more concentrated (Figure 3).

Table 1. Catches (t), fishing effort (days) and catch per unit effort (CPUE, in kg/hm) in the Quebec commercial sea cucumber drag fishery from 2008 to 2010.

Year	Unit B				Unit C				Unit HSP			
	TAC (t)	Catch (t)	Effort (hm)	CPUE (kg/hm)	TAC (t)	Catch (t)	Effort (hm)	CPUE (kg/hm)	Quota (day)	Catch (t)	Effort (hm)	CPUE (kg/hm)
2008					200	201	512	392				
2009	600	135	45	296	800	324	748	433	35	113	483	234
2010	600	23	131	172	800	292	771	379	70	361	1448	249
Average		**79**	**88**	**234**		**272**	**677**	**401**		**237**	**966**	**242**

The size structures of sea cucumbers sampled at sea show maximum sizes of about 230 mm in this study (Figure 4), far from the maximum size of 350 mm mentioned for Quebec. The mean size of individuals caught by dive harvesting in Unit A (116 mm) was much lower than that observed in Unit B (144 mm), Unit C (146 mm) and Unit HSP (139 mm). Note that harvesting in Unit A is mainly carried out at depths of between 5 and 15 m, the usual depth at which sea cucumber nurseries are found. This may partly explain why the Unit A trials were not profitable in 2009. Between 73 and 92% of the sea cucumbers caught in all units were greater than 100 mm, which is the upper limit of the estimated minimum size at sexual maturity for populations in Quebec.

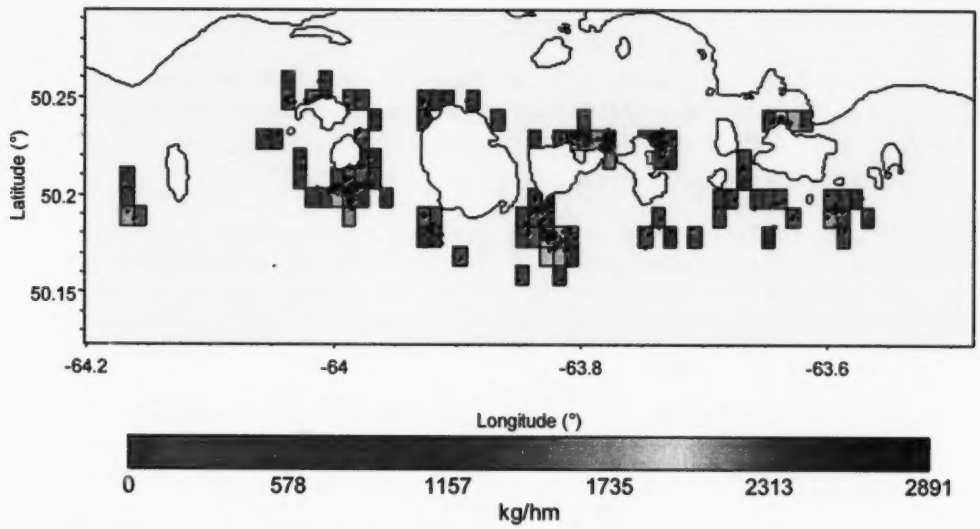

Figure 3. Distribution and concentration (kg/hm) in Unit HSP for the 2010 commercial sea cucumber fishery.

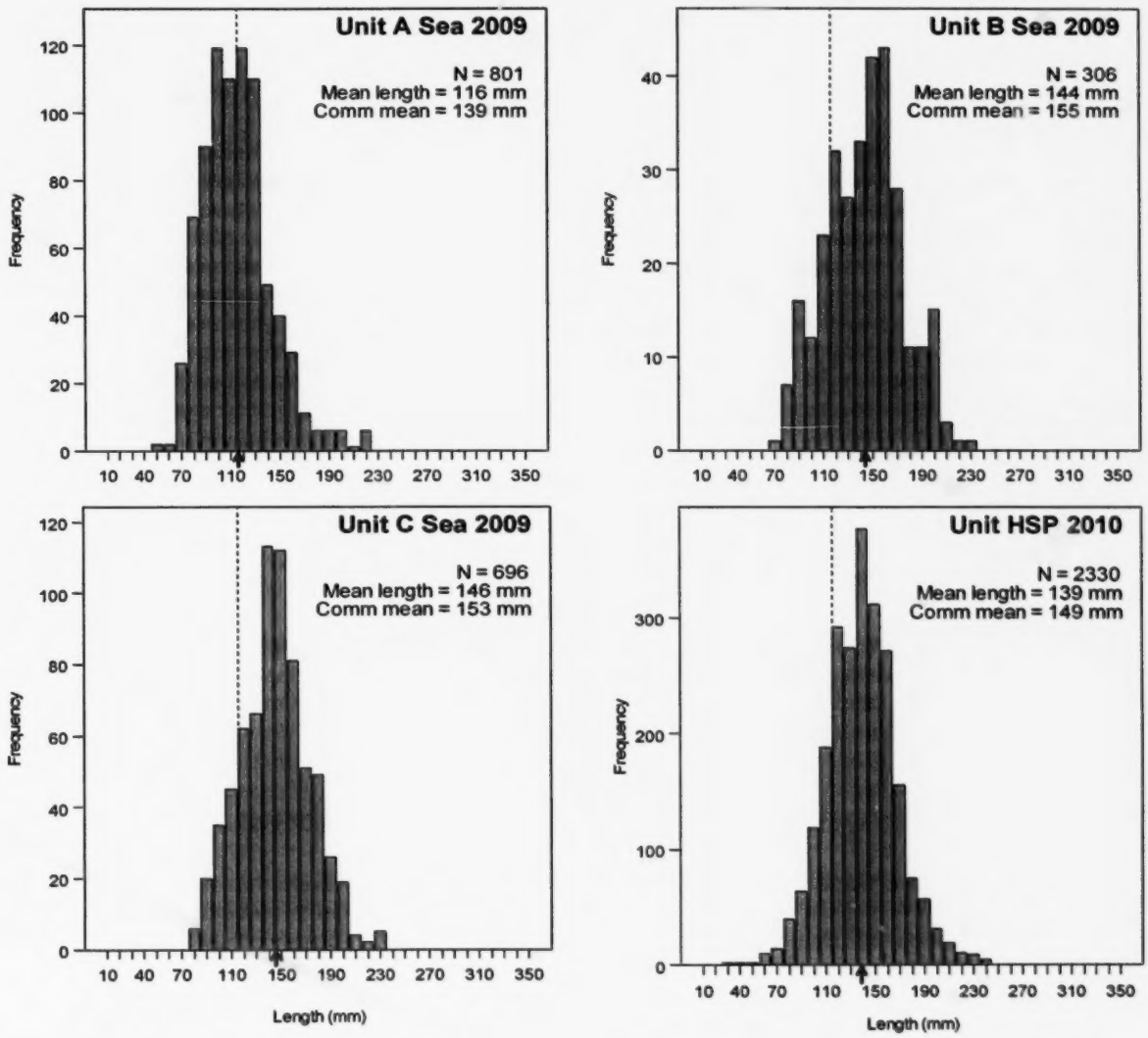

Figure 4. Size structure and number (n) of sea cucumbers caught in dive fishing (Unit A in 2009) and drag fishing (Units B, and C in 2009 and Unit HSP in 2010), measured at sea. The vertical dotted line represents the minimum catch size of 116 mm. Note that this value was applied only in Unit HSP. The "Comm mean" value represents the mean catch size when applying the minimum size of 116 mm. The arrow shows the mean size of all individuals harvested.

Research Survey

Exploratory fishing was carried out in the Mingan region in July 2010. The boat, crew and dredge were similar to those used in the commercial fishery in Unit HSP, also in the Mingan region. Data on the distribution and abundance of sea cucumbers and by-catch species were collected from 33 transects. These transects ran perpendicular to the shore and were spaced over 96 kilometres of coastline, between Île-aux-Perroquets in the west and Rivière de la

Corneille near Baie-Johan-Beetz in the east. At each of three target depths along the transects (10 m, 20 m and 40 m), a dredge was towed for about 500 m in a direction running parallel to the coast. (Additional tows at a depth of 60 m were carried out at six selected sites). In total, 129 tows were made: 20 between 12 and 18 m, 65 between 19 and 37 m, 38 between 38 and 55 m and 6 at a depth of more than 56 m.

The results showed that sea cucumber distribution is not uniformly spread across the territory. Rather, sea cucumbers are found in areas of high and low density (Figure 5). Distinct high and low densities of sea cucumbers were also observed in the commercial fishery carried out by the same harvester in the western half of the survey area (transects 1 to 17). Sea cucumbers are about four times more densely populated (0.060 ind/m^2 or 72.5 kg/hm) in the western half (ending near Havre-Saint-Pierre) than in the eastern half (0.015 ind/m^2 or 19.0 kg/hm).

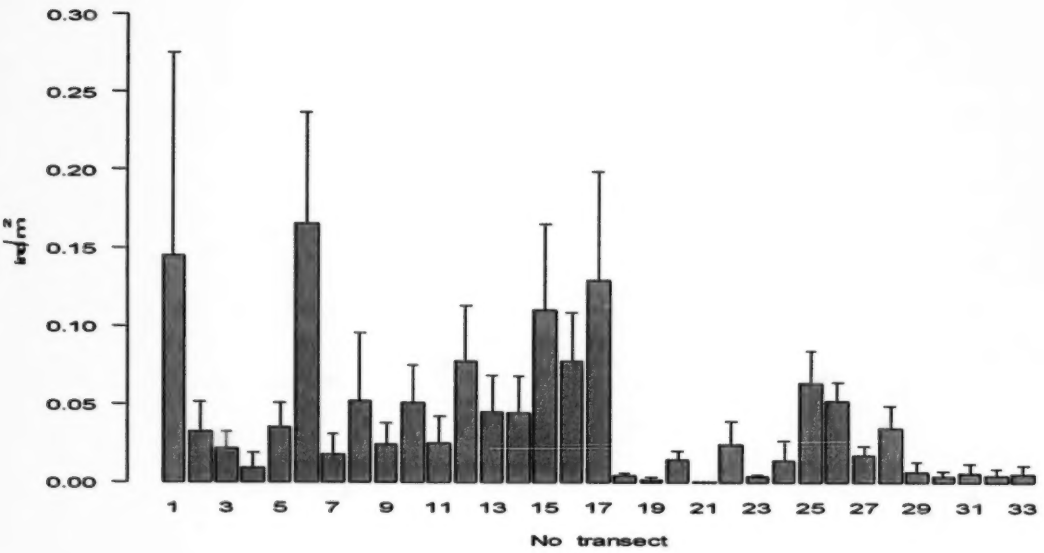

Figure 5. Sea cucumber abundance (individuals/m^2) sampled from 33 transects in the research survey conducted in the Mingan region in 2010. The error bars represent standard deviations.

The mean size of individuals sampled in the 12 to 18 m stratum is 116 mm—much lower than that observed in the deeper strata (Figure 6)—but this is because of a second mode made up of small cucumbers less than 30 mm in size that are not found in the other strata. This is consistent with the literature, which suggests that sea cucumber nurseries are normally found at depths of less than 20 m. As they grow, sea cucumbers slowly migrate seaward. The largest mean sizes were found in the 19 to 37 m stratum and in the 38 to 55 m stratum (149 mm for both). A smaller mean size (137 mm) was observed in the 56 to 73 m stratum; this figure, however, is based on a small number of tows (5). No tows were made in the 0 to 11 m stratum, and only one tow was made deeper than 74 m. Lacking sufficient data, we were unable to accurately determine sea cucumber size at these depths.

Green sea urchins, with a mean of 0.49 ind/m^2, represent the majority of by-catches caught by dragging - 10 times the number of sea cucumbers caught (0.04 ind/m^2) (Figure 7). These results

reflect the nature of systematically dragging without seeking to maximize the harvest of the target species. In a commercial fishery setting, the results would likely be different as commercial harvesters would aim to maximize cucumber yield and minimize by-catch. The number of individuals caught as by-catch as well as the number of species caught as by-catch may vary at certain times of the year, such as the migration periods for certain crustaceans. Fishing gear should therefore be designed in such a way as to reduce catches of non-target species.

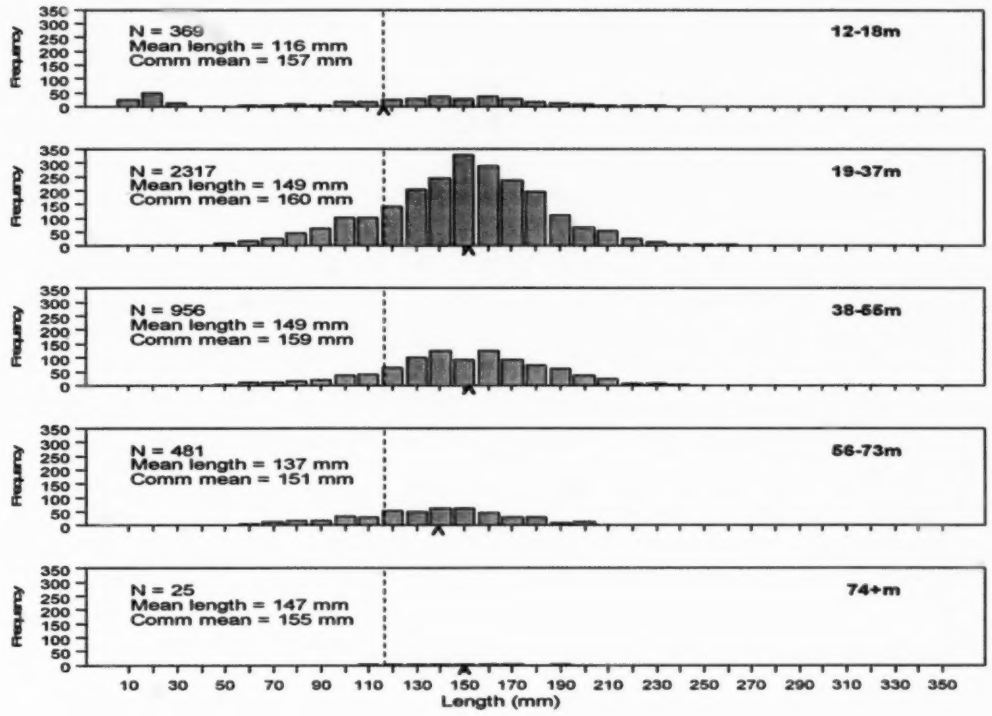

Figure 6. Size structures of sea cucumbers, by stratum, collected from transects during the 2010 research survey conducted in the Mingan region.

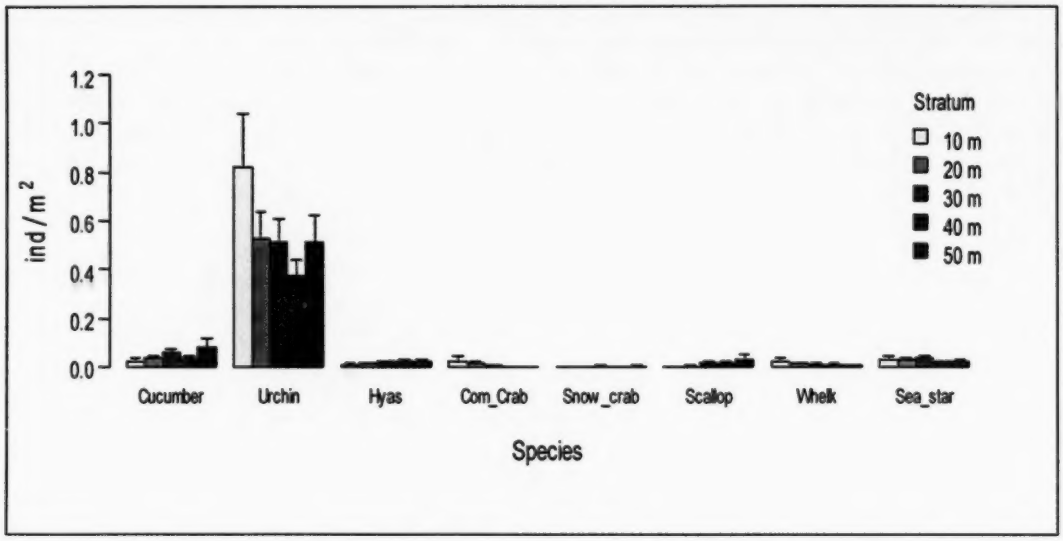

Figure 7. Number of captured individuals (individuals/m^2) of different species, by stratum (m), during the 2010 research survey conducted in the Mingan region. The error bars represent standard deviations.

Impact of Fishing Gear

Since the 1990s, it has been recommended that the use of towed gear in emerging fisheries of coastal benthic species be limited, with diving being favoured as a means of harvesting to protect benthic habitats, particularly in areas serving as nurseries. It was the industry's responsibility to demonstrate that the proposed fishing gear would minimize short-, medium-, and long-term impacts on habitats at all stages of the life cycle of species harvested as well as on the benthic habitat as a whole.

An initial study was conducted in September and October of 2004 on the north shore of the Gaspé Peninsula, between Matane and Cap Gaspé, to determine the potential of a sea cucumber fishery in this region and to test the impact of a 3-m-wide LGS-type dredge on the habitat and on the species caught (Campagna *et al.*, 2005). The conclusions from the study indicate that the dredge is not very selective for the target species. However, the authors acknowledge that the sites used in the commercial fishery often have a higher density of sea cucumbers and a lower diversity of animal species than the sites chosen for the purposes of the study. Therefore, even though snow crabs were one of the species caught in the study, this species is not usually found on the same grounds as the sea cucumber. The common crab, by contrast, is more vulnerable to drag fishing because it is found on the same grounds as the target species. The green sea urchin was captured three times as often as the sea cucumber, especially between 10 and 30 m. Sea stars were also caught, but in fewer numbers. With the exception of juvenile snow crabs, the above-mentioned species experienced minimal physical harm from the LGS dredge. The study nevertheless showed that other by-catch species were damaged by the fishing gear, particularly animals with no rigid exoskeleton, such as corals of the genus *Gersemia*, sponges and sea squirts.

A second study conducted between July 31 and August 11, 2006, west of Rivière-au-Renard, was intended to complement the first study, firstly by gathering more data on the short-term

effects of dredging and secondly by suggesting modifications to the fishing gear. The results of the second study were unfortunately not available at the time of writing. Nevertheless, it remains the responsibility of the industry to develop gear that is more selective and less damaging to the environment. Basing our observations on fishing with the gear currently in use, we identified between 17 and 24 taxa as by-catch in the exploratory fishery carried out in 2009 and 2010 in Units B and C in north Gaspé. This represents between 9 and 36% of the total number of individuals caught.

Even before the results of a more detailed study become available, certain precautionary measures could nevertheless be implemented as part of a sustainable fishing plan. One such measure would be to exclude areas less than 20 m deep from drag fishing in order to conserve nurseries and to protect young individuals, both for sea cucumbers and for other coastal species. By restricting drag fishing to depths of more than 20 m, the sea cucumbers would be caught at their maximum size, and there would also be fewer urchins and common crabs. A second precautionary measure would be to designate a fishing period that takes into account the seasonal movements of species such as the American lobster and the snow crab, so as to minimize the impact of dragging. Another important consideration for species with low mobility, such as the sea cucumber, would be to create refuge areas such as the protected areas that were established in the Gaspé Peninsula in 2010. By ensuring the presence of source populations, we improve the species' chances of reproductive success. Another possibility would be to harvest sea cucumbers from different beds on a rotation schedule, in order to avoid placing fishing pressure on the same beds and to allow the small, unharvested individuals to reach a reproductive size. Finally, the use of dive fishing whenever feasible also represents an alternative that is less harmful to the ecosystem.

Sources of Uncertainty

The sea cucumber fishery is currently done using fishing gears still in development and differing greatly from one sector to another. CPUE estimates between these sectors could be influenced by these differences. In addition, fishing techniques favored by harvesters, such as dredging speed, cable length, towing direction relative to the current and the towing duration, may also have an influence. Furthermore, only a portion of the licensed area for fishing is currently operated by each harvester. Interannual variations are possible if they do not visit the same sites from one year to another.

The mean sizes of sea cucumber measured at sea or landed are directly influenced by the technique used by the sampler to ensure that all individuals are sufficiently contracted.

The conclusions of this advice also depend largely on the quality of the information obtained with logbooks completed by fishermen and purchases slips collected at the dock. Any omissions or errors will influence the parameters estimation of cucumber stocks calculated from the data collection tools.

CONCLUSION AND ADVICE

Drag Fishing

Drag fishing for sea cucumbers is still in the exploratory stages in Quebec; only the north shore of the Gaspé Peninsula and one part of the Mingan region are currently being fished. Since the fishery is so new, we lack sufficient knowledge at this time to be able to determine an acceptable exploitation rate. The TACs established for Units A, B and C may therefore prove unsustainable over the medium and long terms and will need to be reassessed as new information becomes available. Effort control may be the most appropriate way to manage this type of fishery. For this and all other emerging fisheries, any increase in fishing effort must be achieved gradually and even then only if catches are at the maximum granted quota and if the stock status has been stable or improving for a number of years. Furthermore, the differences already observed between the units suggest that management regimes should be developed specifically for each locale.

The gear currently being used must be improved so as to minimize by-catches and damage to habitats. The short-, medium- and long-term impacts of this gear must still be determined.

Dive Fishing

To date, the harvesting of sea cucumbers by underwater diving has been attempted by only one harvester. Because this technique appears to have a low impact on the sea cucumbers and their habitat, it remains the preferred method for commercial sea cucumber fishing. The use of siphons in dive fishing should however be assessed more rigorously.

OTHER CONSIDERATIONS

In almost all cases around the world, sea cucumbers are harvested commercially without the use of sophisticated equipment. They are usually collected by snorkelling, often in sites close to where the harvester lives. Despite the harvesters' rudimentary methods, several stocks have collapsed and do not show signs of recovery. This raises the question: What lies in store for the *Cucumaria frondosa* in our waters if they are fished as intensively as planned? We have no information on the resilience of sea cucumber stocks at this latitude as compared to those in more temperate regions. Since it will be years before we can answer these questions, we must exercise caution when making decisions and developing management strategies.

We must work to improve our knowledge, which is still lacking in many areas, notably the cartography of sea cucumber beds, the spawning season in our waters, growth rates, the size at sexual maturity in each of the areas being fished, as well as the impact of the fishing gear on other marine species.

SOURCES OF INFORMATION

This science advisory report is the outcome of a peer review held on May 5, 2011, by Fisheries and Oceans Canada's Canadian Science Advisory Secretariat on the assessment of sea cucumber stocks in Quebec. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs /index-eng.htm.

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